PSAMMOPHILOUS AQUATIC BEETLES IN SOUTHERN CALIFORNIA: A STUDY OF MICROHABITAT PREFERENCES WITH NOTES ON RESPONSES TO STREAM ALTERATION (COLEOPTERA: HYDRAENIDAE AND HYDROPHILIDAE)

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Abstract

Systematic sampling of stream banks along the San Gabriel River in southern California revealed distinct zones of microhabitat preference for adults of the various genera studied (Hydraenidae: *Hydraena; Limnebius; Ochthebius*) (Hydrophilidae: *Chaetarthria; Laccobius*). Limitations on microhabitat utilization by genera appear to result from the interaction of flow rate, slope of the stream bank, size of interstitial spaces, and convexity of the beetles (among other components). Differences in zones of microhabitat utilization by congeneric species, where determined, were also related to beetle convexity and size of interstices. Extensive alterations of the psammic habitat have resulted in restriction of these beetles to the mountainous areas of the drainage system.

Publications regarding habitat preferences of aquatic beetles in the families Hydraenidae and Hydrophilidae are few and provide only short comments based upon field observations (LeConte 1861, Fall 1901, Richmond 1920, Leech 1948, Young 1954, Leech and Chandler 1956). These comments primarily concern strictly aquatic forms found in the benthic zone or amongst floating or emergent vegetation. Ecological studies on hydraenid and hydrophilid beetles found in moist sand and gravel of streambanks are lacking. This ecological zone, the psammon, is also inhabited by a diverse group of non-insectan forms, including ciliates, mites, nematodes, rotifers, and oligochaetes (Hynes 1972).

The purposes of this paper are to present the methodology and some preliminary findings regarding preferences of interracting taxa in the 2 families, and to offer possible explanations, some of a broad and general nature, for the observed distributions. In addition, the observed microhabitat preferences are used as a data base from which statements are generated regarding the effects of stream alteration upon the distributions of these insects. Finally, in hope of stimulating further work, suggestions are given for more detailed study of this problem.

Materials and Methods

The species considered here are tiny beetles which inhabit the ecotonal zone between the stream and the adjacent dry soil. In these habitats the thigmotactic beetles wedge themselves between the sand grains and pebbles and eat microscopic algae and other microorganisms growing upon the moist substratum.

Adults of these taxa are dislodged quite readily by splashing water from the stream or pond onto the shore, using the hand as a scoop. The water flows back down into the stream or pond, washing the minute beetles off the substratum and out onto the surface of the water. The ventral surfaces of these beetles have hydrofuge pubescence which holds a bubble of air used in respiration. This bubble causes the beetle to float upon the surface of the stream and, since the beetle cannot swim, permits its easy collection.

While collecting in the above manner, I observed that if water was repeatedly splashed on a small area of the streambank, a sequence of taxa would be obtained. This observation prompted the development of a simple sampling method to reveal the distribution of these psammophilous beetles within and on the sand bank. The method involves partitioning of the stream bank by using a U-shaped trough constructed of 24 gauge sheet metal. The psammophilous sampler measured 1 inch (2.54 cm) square in cross section and 13 inches in length (Fig. 1).

A psammophilous sample is taken by the following steps: (1) Forcing the inverted U-shaped sampler repeatedly into the stream bank, forming a series of parallel lines (Fig. 1); (2) forcing a knife vertically into the substratum and drawing it along the parallel lines; (3) forcing the U-shaped sampler horizontally into the stream bank (beginning at the waterline) and removing the substratum; (4) placing the subsample so removed into an appropriately labelled container; (5 and 6) repeating steps 3 and 4 until the second 1-inch "layer" is removed (or portions of that layer); and (7) removing portions of the third layer.

At the conclusion of the sampling, a small channel perpendicular to the stream is dug at the margin of the area that has been sampled. After water has flowed into the channel and reached the level of the stream, a number of vertical measurements are made (using the surface of the water in the channel as the baseline) to ascertain the slope of the stream bank.

The individual samples are then placed in a porcelain tray and water slowly added as the substratum is vigorously agitated. This dislodges the adult beetles, which float to the surface and are removed with a fine mesh nylon net and placed into appropriately labelled vials.

The results of such sampling can be graphically presented to illustrate the location of each beetle and the slope of the bank (Figs. 2, 4-7). Each subsample made by the trough is represented by 1 square "cell" on the figure (or, as the case at the waterline, portions of a "cell"). Each cell therefore represents a section of stream bank 1 inch square and 13 inches long (parallel with the stream). In the figures, "H" represents the water level of the stream, numbers along the "H" axis represent horizontal inches perpendicular to the waterline, and "V" represents vertical inches below the surface of the stream bank. The diagonal lines represent those portions of the stream bank not sampled. The English system of measurement was purposely selected so that the designation of each cell would represent its location relative to the waterline and the stream bank surface. For instance, cell H5V2 would be that area which was 4-5 horizontal inches from the waterline and 1-2 vertical inches below the surface of the stream bank.

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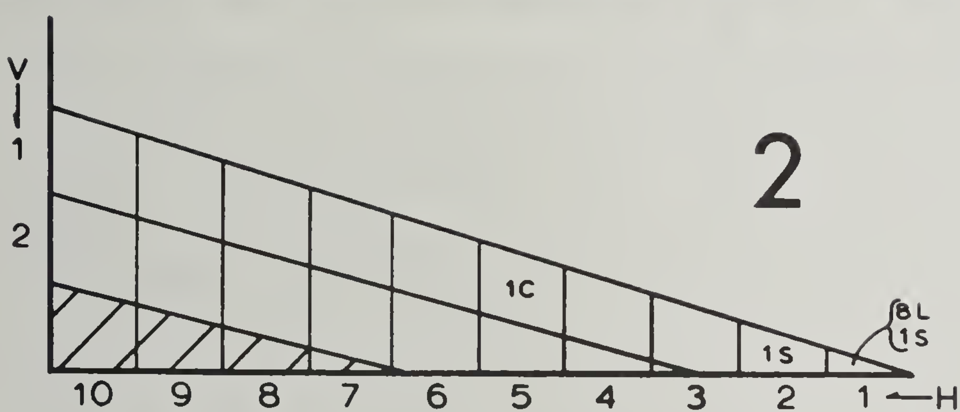

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Figs. 1-3. 1) Photograph of site of psammophilous sample no. 1 (at the beginning of the sample). Note U-shaped trough and parallel lines on stream bank. 2) Psammophilous sample no. 1 (C = *Chaetarthria,* L = *Laccobius,* S = *Ochthebius*). Numbers along the horizontal axis represent inches from the waterline. Numbers along the vertical axis represent inches below the surface of the stream bank. Each square "cell" represents a section of stream bank which is one inch square, thirteen inches long, and lies parallel to the waterline. Area with diagonal lines indicates portion of stream bank not sampled. Refer to appendix for detail of specimens collected. 3) Site of psammophilous sample no. 2 at conclusion of study.

Discussion of the Samples

Sample No. 1

The substratum of this sample (Fig. 1) consisted of homogeneous fine sand. The sand was extremely wet, as would be expected from the low slope angle of the bank (Fig. 2). The stream at this point was moving, but quite slowly. *Laccobius* preferred cell H1V1, with 8 specimens collected in that subsample and none in the remainder of the area studied. One specimen of *Ochthebius interruptus* LeConte was also found in cell H1V1. Cell H5V1 contained a single *Chaetarthria*. The sample was made in the afternoon of October, 1971.

Sample No. 2

This sample was taken at midday in the month of November, 1971, on the West Fork of the San Gabriel River (Fig. 12:2). The substratum was heterogeneous, consisting of a gradation of particle size from fine sand to 3-inch diameter stones (Fig. 3). The current was moderate. *Laccobius*, as in Sample No. 1, was again found in cell H1V1, but now in association with the hydraenids *Limnebius* and *Ochthebius* (Fig. 4). The hydraenids were found in cells H1V1-H4V1 only, with the greatest concentration in cell H1V1. The hydrophilid, *Chaetarthria*, was seen to have a decided preference for the upper regions of the stream bank, with the distribution beginning at cell H7V2 and continuing to cell H29V1. Four species of *Chaetarthria* (see appendix) were taken at this site. The only species preference noted was the distribution of *Chaetarthria pallida* (LeConte) at the region of the sample farthest from the stream.

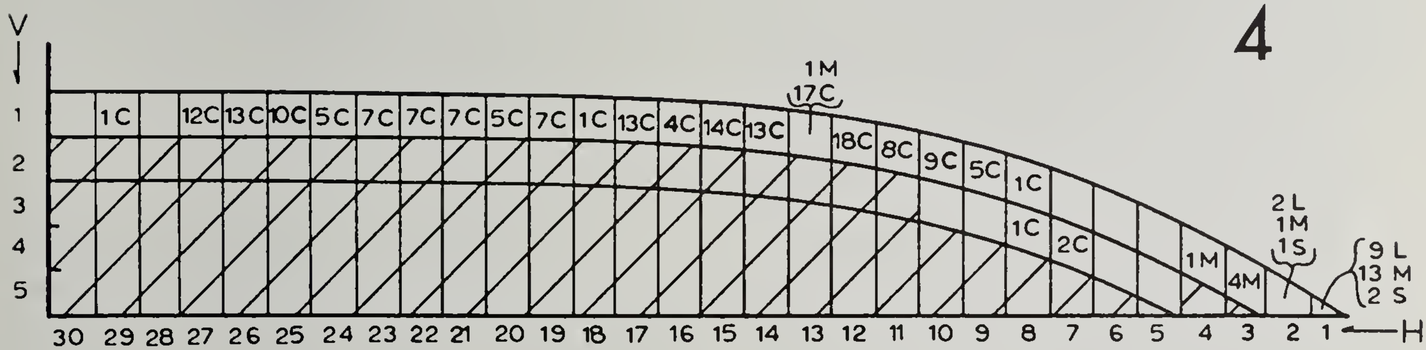
The rapid decrease in numbers of *Chaetarthria* at the upper limits of the study (Fig. 4:H28-H30) was undoubtedly due to the presence of a footpath, the edge of which was intersected by the sample (Fig. 3). The substratum at this point was very compacted, the larger particles forced downward so that the interstices separating them became tightly packed with smaller particles.

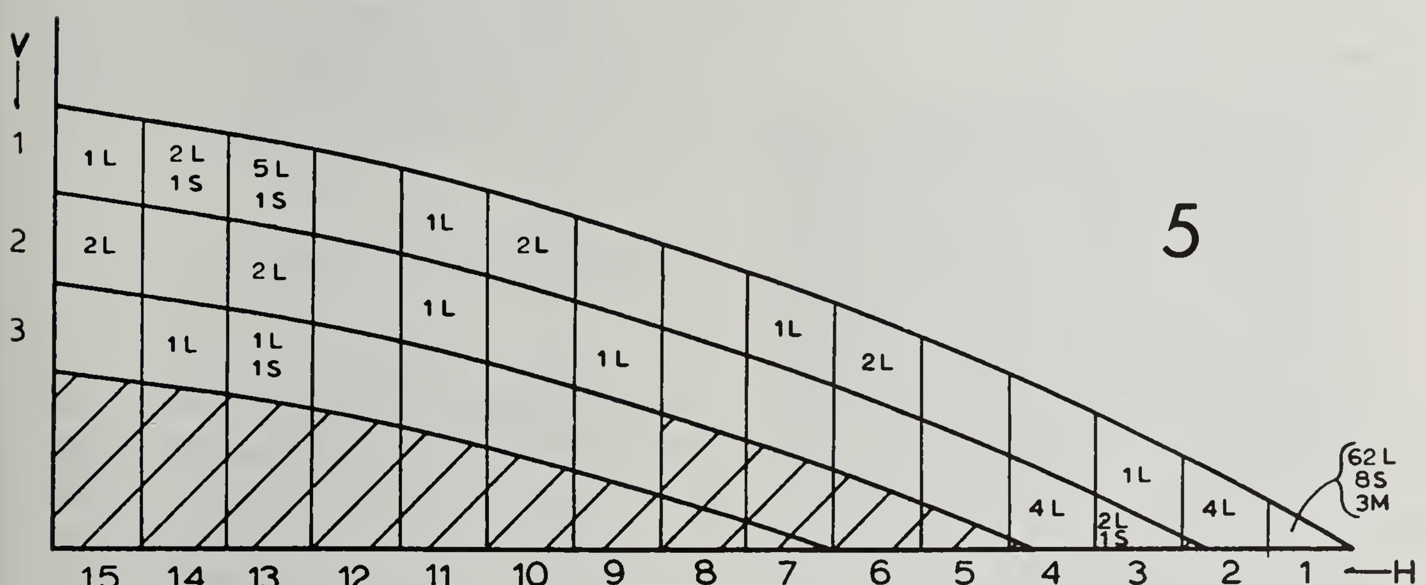
The single *Limnebius* found in cell H13V1 was a teneral adult; the location of this specimen probably reflects the region of pupation selected by *Limnebius* larvae. The larvae of *Limnebius* are semi-aquatic, and one would expect to find them in the general region utilized by *Chaetarthria*.

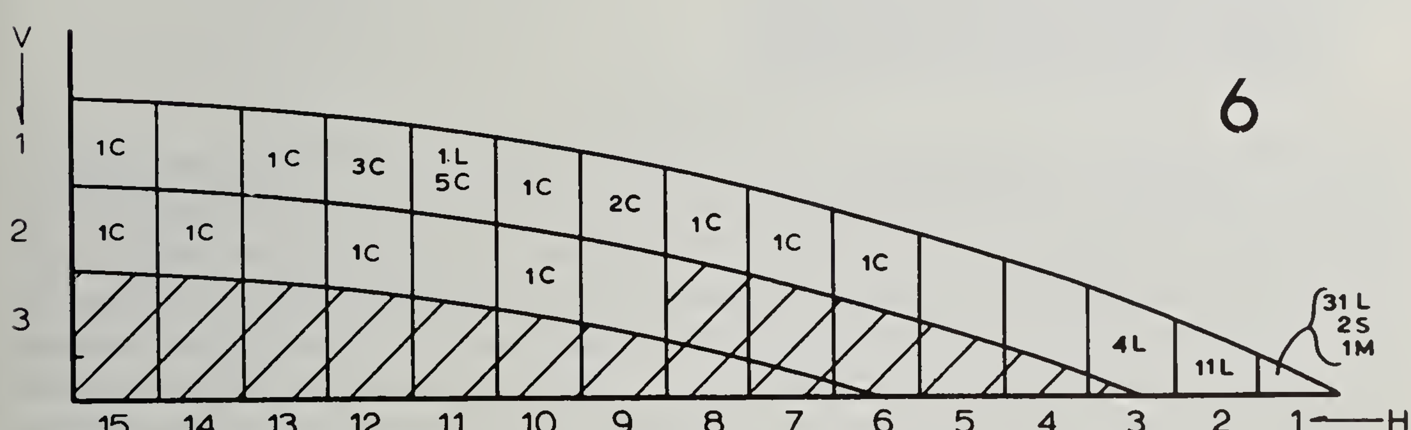
Sample No. 3

Figure 5 illustrates the distribution within a sand bank of a backwater pool (approximately 6 feet in diameter) located on the West Fork of the river (Fig. 12:2). No current was visible in the pool, and the substratum of the bank was wet and composed primarily of what might be described as homogeneous sand. By this I mean that there was very little variation in particle size within the bank. A concentration of *Laccobius,* including 4 species (see appendix), was found at the waterline (H1V1). The scattered individuals of *Laccobius* which were collected farther up the bank were observed to be moving toward the pool (on the surface of the sand). The sample was taken in the early morning (October, 1971), and it may be that this distribution reflects nocturnal activity high on the stream bank, whereas most diurnal activity takes place near the waterline.

Those specimens taken from the third vertical layer are presumably due to sampling error. This occurs when a specimen in an upper layer is exposed by removal of a sample and subsequently crawls to the next vertical layer before its true location is sampled. These beetles must obtain atmospheric air periodically, which would seem to be quite difficult from a depth of 3 inches in a substratum the interstices of which were filled with water.







Figs. 4-6, Psammophilous samples 2-4, refer to Fig. 2 and text for explanation (C = *Chaetarthria*, L = *Laccobius*, M = *Limnebius*, S = *Ochthebius*): 4) sample no. 2; 5) sample no. 3; 6) sample no. 4.

Both *Ochthebius interruptus* LeConte and *Limnebius* sp. also displayed a decided preference for cell H1V1.

Sample No. 4

This sample (Fig. 6) was taken not far from Sample No. 2 (Fig. 4). The substratum, however, consisted of homogeneous sand. The flow rate of the stream was slow. Although *Chaetarthria* was present in its typical distribution pattern, a much larger proportion of the specimens were *C. pallida*. *Laccobius* again displayed its preference for cell H1V1, where it was taken in association with 2 *Ochthebius* and only 1 *Limnebius*.

Sample No. 5

This sample (Fig. 7) was taken on the West Fork at an elevation of 3100 feet (Fig. 12:1) in November, 1971. The substratum was heterogeneous (fine sand to 1/4 inch diameter pebbles), and the flow rate was moderate (Fig. 8). The area was extremely productive, with a total of 307 beetles collected. The hydraenids *Limnebius* and *Hydraena* predominated at the waterline, with the preferred cell being H3V1. *Chaetarthria* again was seen to be characteristically distributed up the stream bank, but in this instance in association with *Ochthebius puncticollis* LeConte. At the upper limits of the sample (Fig. 7:H36V1), the roots of a tree were encountered. The particles exhibited a gradation of size from pebbles at the surface to very fine grains at 3 inches below the surface (Fig. 9).

Results in Terms of the Genera

Laccobius

Psammophilous sampling revealed that members of this genus in the study area occupied a distinct zone on the stream bank. Differences in habitat preferences among the 4 species, however, were not determined. The distribution preference in Sample No. 3 was dramatic, with 62 individuals, including representatives of all 4 species, present in the first inch of substratum (Fig. 5:H1V1), and only scattered individuals present above that zone. The other sampling studies revealed similar distributions. A decrease in number of individuals, however, was seen in studies of banks that bordered flowing water. In these situations, the adults of *Limnebius* and *Hydraena* would predominate.

Chaetarthria

All 5 species of *Chaetarthria* found in the San Gabriel River occupied a distinct zone of preference within the stream bank. This zone began at a distance approximately 5 inches from the waterline and extended as much as 36 inches up the bank. Most specimens were taken in the upper inch of substratum. This zone was the area of stream bank which had undergone sorting of particles, resulting in a gradation of particle size. Upper limits of distribution were caused, I assume, by the lack of appropriate interstitial spaces due to the absence of particle sorting processes. A related phenomenon with respect to habitat has been seen in the dryopoid aquatic beetle, *Psephenus* (Murvosh 1971).

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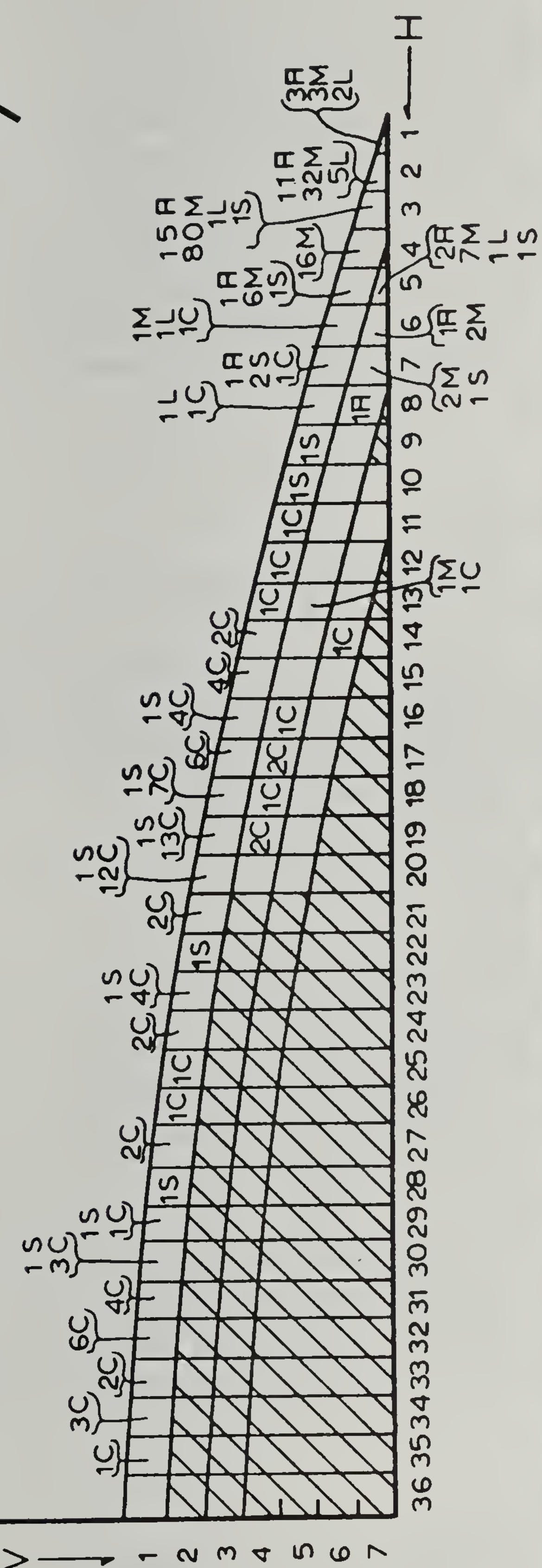

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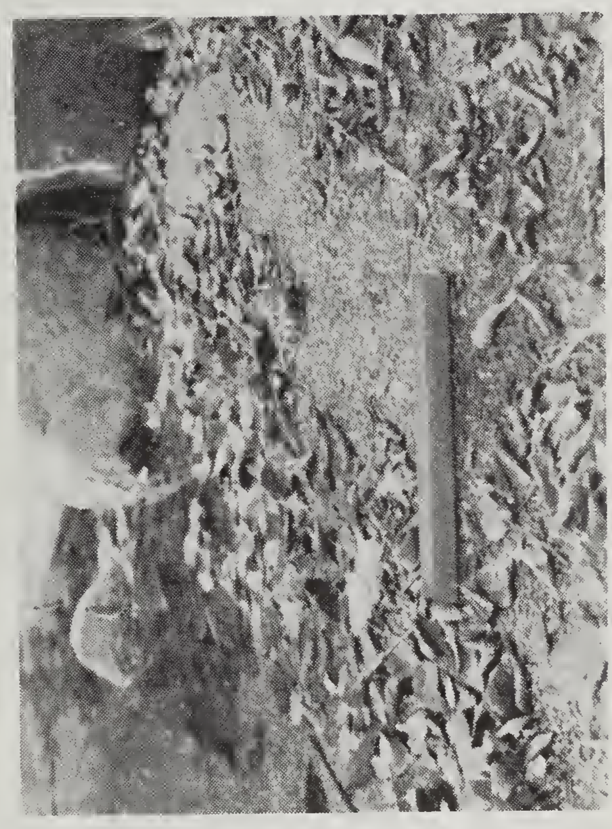


Figs. 7-9, Psammophilous sample no. 5: 7) graphic representation of distributions and slope of bank, refer to Fig. 2 and text for explanation and to appendix for detail of specimens (C=*Chaetarthria*, L=*Laccobius*, M=*Limnebius*, S=*Ochthebius*, A=*Hydraena*); 8) photograph of site before sampling (leaves were removed before sampling was initiated); 9) photograph of the margin of the sample at the conclusion of substratum removal (note the gradation of particle size, from pebbles at the surface to fine sand grains at three inches below the surface).

Exact microhabitats of the separate species of *Chaetarthria* were not determined; certain trends, however, were noted. The species *C. pallida* was encountered in increasing numbers at the upper limits of the zone of preference for the genus. This was the only species of the genus taken at Whittier Narrows (Fig. 12:11). The habitat at that locality consisted of the margin of a man-made lake. Water movement was not present in the lake, and the shore was composed of fine sand. Beetles which were dislodged by splashing water on the bank were observed to crawl rapidly back up the bank and begin to burrow into the sand at a distance slightly less than a yard from the waterline. I consider it significant that *C. pallida* was the smallest member of the genus collected in the study area, and also the species that occupied the area with the smallest interstices (Fig. 10b). Leech (1948) reported that species of this genus are nocturnal.

Ochthebius

Ochthebius interruptus LeConte, *O. discretus* LeConte, and *O. lineatus* LeConte preferred cells H1V1 and H2V1 (Figs. 2, 4, 5, 6). *O. puncticollis* LeConte, however, was encountered as much as 30 inches from the waterline and was more or less evenly distributed up the stream bank (Fig. 7). In this sample, as in all other samples, *Ochthebius*, regardless of species, overwhelmingly preferred the uppermost inch of substratum.

Hydraena

Hydraena sp. found in the San Gabriel River displayed a very definite preferred zone of activity within and on the stream bank (Fig. 7). The preferred zone of activity for adults, as indicated by the total number of individuals collected, was H2V1 and H3V1. This zone, in Sample No. 5 (Fig. 7), contained 26 specimens, while the number of specimens decreased drastically on either side of that zone. Specimens of the genus were not encountered beyond approximately 8 horizontal inches from the waterline. The reasons for the upper limit were not determined, but it is presumed that wetness of the substratum is an important factor. This explanation is corroborated by the fact that the zone of activity of the hydrophilid *Chaetarthria*, which was collected in moist, but not wet situations, began 2 inches above the upper limits of *Hydraena* sp.

Limnebius

Limnebius found in the San Gabriel River preferred the area of the stream bank approximately 1 inch to 3 inches from the waterline. The adults also preferred the margin of a stream where the water was flowing, instead of a backwater pool where there was little or no current. This is demonstrated by a comparison between Figs. 5 and 7. In Fig. 5, only 3 specimens were collected in the total sample, whereas in Fig. 7, 80 specimens were collected in the single cell H3V1. The preference of the area 1 inch to 3 inches from the waterline is graphically represented in Fig. 7, where 112 specimens were collected in that area, whereas only 38 specimens were collected outside that area. As in the genera *Ochthebius* and *Hydraena*, the uppermost inch of substratum was preferred.

Interpretations and General Considerations

Habitat preferences of certain genera, and in some instances species, seem to be closely correlated with the interstitial space size of the substratum. The size of interstices is, of course, a reflection of the particle size. That is, the larger the particles, the greater the size of interstices, and conversely, the smaller the particles the smaller the interstices.

The interstices used by these beetles must be relatively devoid of silt, which would fill the cavities and prevent both food-getting and respiration. The lack of interstices appears to be the logical explanation for the vertical limits on the distribution of the various genera studied here. I assume that precipitation and water splashing from the stream onto the bank cause the smaller particles to be washed downward, thereby sorting the particles by size, with consequent formation of interstices in the upper inches.

The horizontal distribution (distance from the waterline) appears to result from the interaction of a number of factors, including size of interstices, convexity and hydrophilic preferences of the beetles, flow rate of the stream, and slope of the bank (which partly determines the amount of moisture present).

The preferred location of the beetle genera within the stream bank displayed a direct correlation between size of interstices and convexity of the beetles (Fig. 10). *Chaetarthria*, which has been shown to prefer the area with greatest size of interstices, is the most convex beetle in the study area (Fig. 10 a and b). This genus has the ability to partly roll into a ball, undoubtedly a defense against predation. The most convex hydraenid, *Ochthebius*

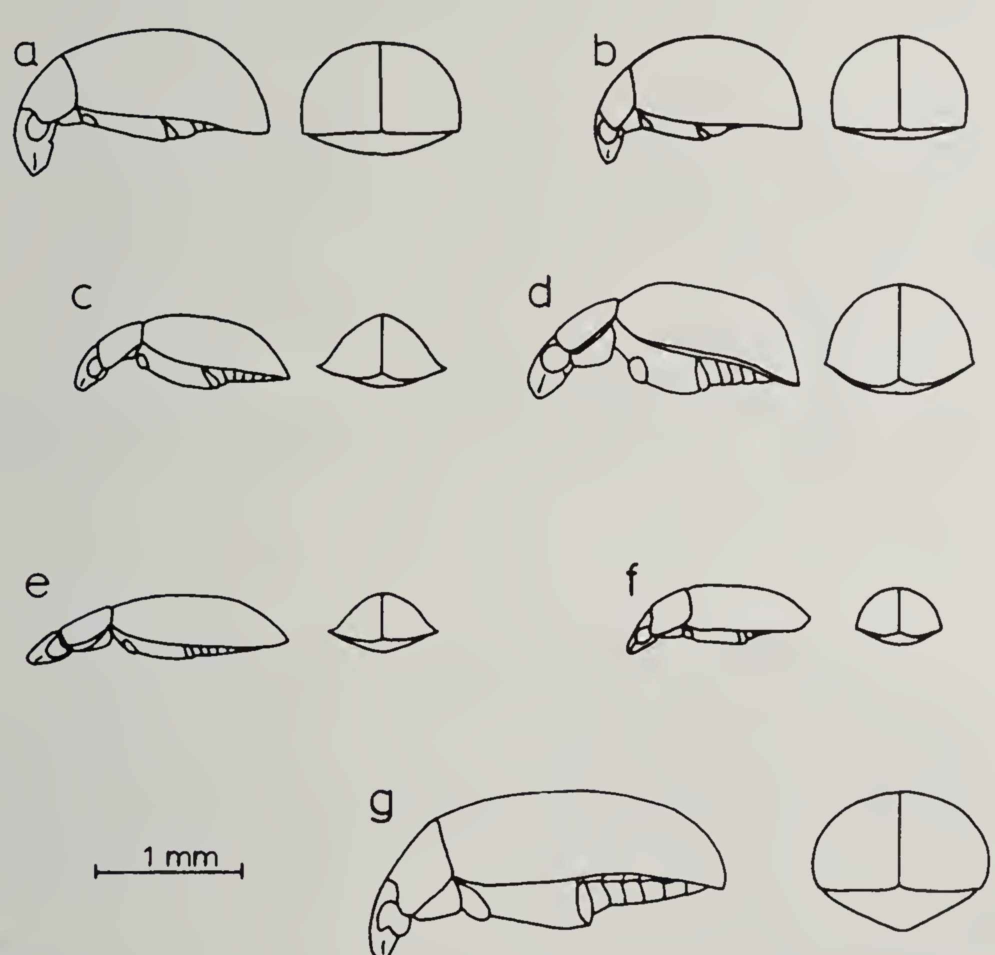


Fig. 10. Lateral and posterior views of psammophilous aquatic beetles (a = *Chaetarthria nigrella*, b = *Chaetarthria pallida*, c = *Ochthebius interruptus*, d = *Ochthebius puncticollis*, e = *Hydraena* sp., f = *Limnebius* sp., g = *Laccobius californicus*).

puncticollis (Fig. 10 d), also occupied the area with the greatest size of interstices. Convexity, in the area close to the waterline, would be a limiting factor due to the resistance it creates against flowing water. *Hydraena* and *Limnebius* (Fig. 10 e and f), which are extremely flattened, occupy this zone if the flow rate is moderate.

Laccobius appears to generally displace *Limnebius* in areas of slow flow rate, and conversely, *Limnebius* appears to be more adapted to areas of fast flow rate than *Laccobius* (Fig. 11). The small size of *Limnebius* would allow them to utilize smaller submerged interstices in cell H3V1 in areas of moderately fast water. This would allow them to seek refuge beneath the surface of the substratum in times of rapid rise in stream level due to precipitation. Their relatively flattened form would also be an aid to withstanding the pressures of flowing water. However, as Fig. 11 illustrates, the peak of utilization lies between 2 and 3 inches from the waterline, indicating perhaps that flow rate at the waterline is a limiting factor for *Limnebius*.

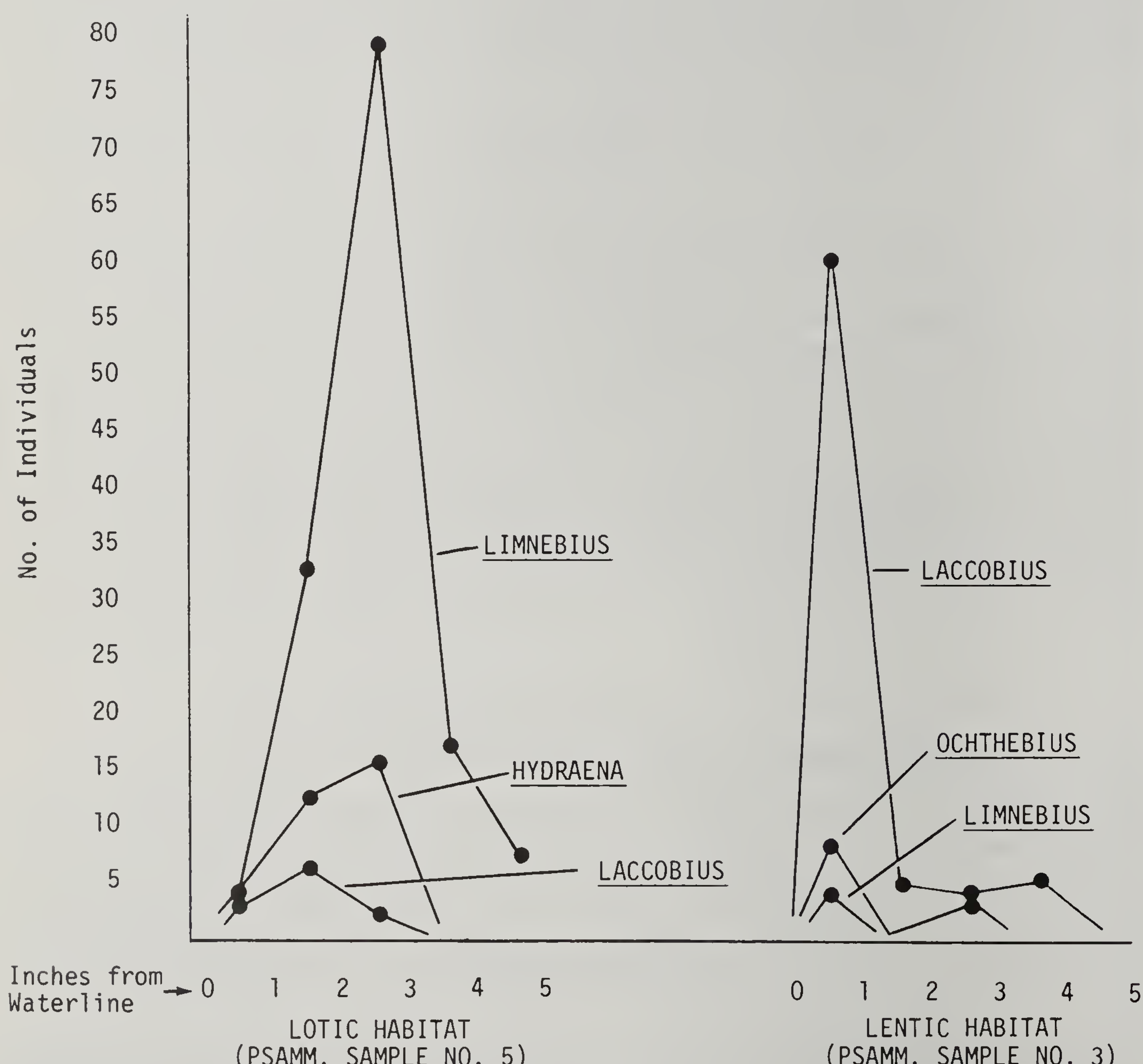


Fig. 11. Effects of flow rate on Coleopterous components of the psammic zone.

Laccobius, on the other hand, is much larger and would be unable to seek refuge between particles to the extent that *Limnebius* does. Also, their convex body form (Fig. 10g) would present much more resistance to the flowing water.

Laccobius is a very weak swimmer, and this would allow the species to more effectively utilize the area at and just slightly below the waterline (in areas of slow or non-existent flow rate). *Limnebius*, being unable to swim, would need substratum to reach the surface to obtain atmospheric air for respiration. This would restrict their use of the area immediately below the waterline.

However, this does not explain the absence of *Limnebius* in cell H3V1 of Samples No. 1, 3, and 4. One major difference between the substratum of those samples and that of the samples which did contain *Limnebius* in cell H3V1 was that the interstices of the former samples were filled with water, whereas those of the latter were not. Perhaps this indicates that the lack of air-filled interstices is an important limiting factor for *Limnebius*.

The degree of water saturation of the psammic zone is intimately interrelated with the slope and permanence of the stream bank. Relatively saturated banks generally have a much lower slope angle and are much more frequently being washed downstream and redeposited, whereas relatively unsaturated banks are generally much more permanent and have a higher slope angle. The frequent mixing of particles in the relatively saturated and impermanent banks results in more uniform particle size and prevents any vertical sorting of particles. Relatively permanent banks, however, do not have the particles mixed frequently and the banks are high enough above the water level of the stream to allow percolation of rain water and water splashing from the stream, with the consequent sorting of particles.

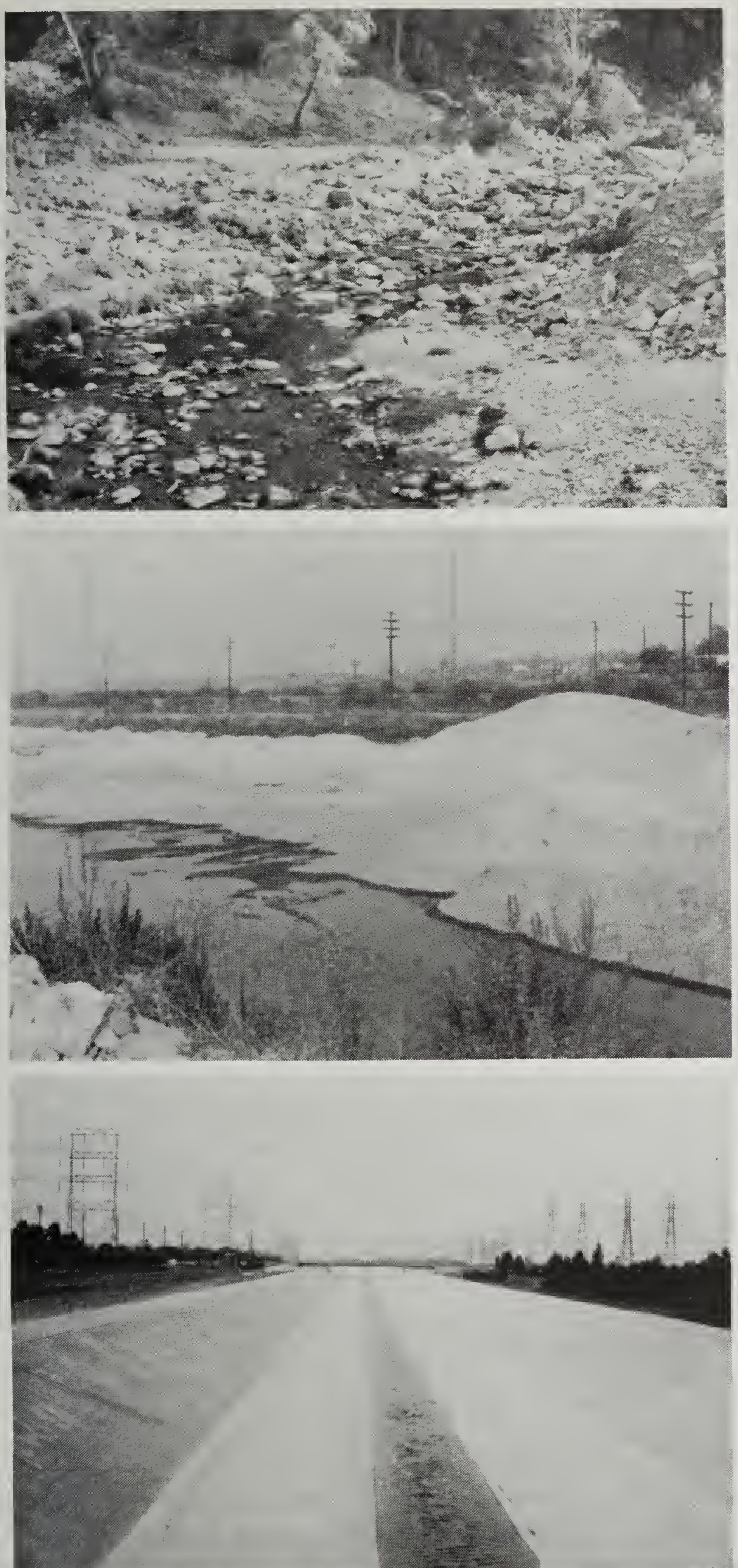
It would appear then that physical limiting factors acting upon the adults, rather than competition, are the primary causes of the observed distributions of these 2 genera. However, it should be noted that the *larvae* of the hydraenids are only semi-aquatic and require some degree of air-filled interstitial space for feeding and protection from predators. The *larvae of Laccobius*, on the other hand, are totally aquatic and predaceous, living near the waterline. The adult hydraenids oviposit in this area, and the newly emerged larvae remain for a short time beneath the water. They would, therefore, be in an excellent position for predation by *Laccobius* larvae.

Effects of Habitat Alteration

The San Gabriel River in southern California (Fig 12) proved to be an excellent site for this study, not only because of the abundance of these psammophilous forms, but also because the river has received considerable alteration in certain regions.

Young (1954) stated that populations of aquatic Coleoptera are not directly correlated with the volume of water present in an aquatic situation, but with the extent of suitable shoreline. Most aquatic Coleoptera of the families Hydraenidae and Hydrophilidae collected in this study were found to require a more or less permanent shoreline composed of sand, pebbles, and stones.

Fig. 12. San Gabriel River and distribution of the Hydraenidae (I = *Ochthebius interruptus*, L = *Ochthebius lineatus*, P = *Ochthebius puncticollis*, F = *Ochthebius costipennis*, D = *Ochthebius discretus*, H = *Hydraena* sp., A = *Limnebius* sp. A, B = *Limnebius* sp. B).



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Figs. 13-15, San Gabriel River: 13) West Fork in the San Gabriel Mountains; 14) vicinity of Whittier Narrows (note mounds of sand made by bulldozers); 15) vicinity of Bellflower.

A combination of many different types of alteration has destroyed the aquatic Coleoptera habitats of what was previously the lower river. From the Pacific Ocean northward to just south of Los Alamitos, the "river" is a channel with sides composed of granite blocks. From Los Alamitos to just south of Whittier Narrows, the channel is completely cement (Fig. 15). Collecting in the channel did not provide a single specimen for this study, and the area can only be designated "destroyed habitat" relative to the insects in question.

In the vicinity of Whittier also, the San Gabriel River is in a disturbed condition. The "banks" of the river in this region are composed of cement-covered granite blocks, or cement-covered soil. In portions of this area, presumably to facilitate percolation, bulldozers are used to move the substratum in the riverbed from one location to another (Fig. 14). This movement completely destroys the habitats of the psammophilous forms. Species which prefer lentic situations were less influenced by this action. However, portions of the river in this area would be without water for periods of time, presumably due to controls on the upper river. The adult beetles in this study could survive short periods without water, since they are able to fly to other aquatic habitats. The larvae, on the other hand, are flightless and require moisture to prevent desiccation. For these reasons, I designate as "altered habitat" the river in the vicinity of Whittier Narrows.

From just north of the Whittier Narrows area to the base of the San Gabriel Mountains, only 2 extremely small areas had water (in 1972). These areas are designated as 9 and 10 in Fig. 12. The presence of beetles in these areas corroborates the idea that the absence of beetles in the lower portions of the river is not a reflection of altitudinal limitations on distribution.

Most of that part of the river which flows through the San Gabriel Mountains is in a much less altered state (Fig. 13). Alteration of stream habitat, however, has been caused by damming the gorges to form reservoirs. The water level in the reservoirs is high on the sides of the gorge, where there has been little erosive activity. It is well known that erosive activity is one of the major formative agents of the riparian habitat. There are, therefore, suitable habitats for only the most vagile species. Collecting at 1 of the 3 reservoirs, Cogswell Reservoir (Fig. 12: just upstream from 2), revealed only a few specimens of the hydrophilid genus *Laccobius*. Contrastingly, specimens of all 3 genera of Hydraenidae, and the hydrophilid genera *Laccobius*, *Chaetarthria*, *Enochrus*, and *Tropisternus* were collected in numbers approximately 1 mile downstream from the dam. In light of this, the reservoirs are designated altered habitat.

Suggestions for Future Study

The results and interpretations presented here, for the most part, are of a descriptive and general nature. Hopefully they have clarified some of the problems and will serve to stimulate further research in this area. Many components of the psammic zone need more precise elucidation, and perhaps future study might include some of the following techniques and topics: (1) measurements of particle size and water content of the various subsamples; (2) detailed recordings of fluctuations in stream level and the resultant modifications in beetle microhabitat distributions; (3) precise measurements of flow rate; (4) the sequence of recolonization that occurs following torrential flooding; (5) limiting factors acting upon 2 or more congeneric species which have adults of very similar size and shape; (6) to what degree environmental pressures acting upon the larval stages of these insects affect the observed distributions of the adult stages; (7) what species in the past, if any, would have been found in greater numbers in the lower portion of the drainage basin than in the mountainous regions, and what effects their invasion of the mountain psammic habitats would have on taxon interactions.

Acknowledgements

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Appendix

The following species of hydraenids and hydrophilids were found in samples 1, 2, 4, and 5. The alphabetical designations are those used in the detail of specimens:

A. *Limnebius* sp.
B. *Hydraena* sp.
C. *Ochthebius discretus* LeConte
D. *Ochthebius interruptus* LeConte
E. *Ochthebius lineatus* LeConte
F. *Ochthebius puncticollis* LeConte
G. *Laccobius californicus* d'Orchymont
H. *Laccobius carri* d'Orchymont
I. *Laccobius ellipticus* LeConte
J. *Laccobius piceus* Fall
K. *Chaetarthria bicolor* Sharp
L. *Chaetarthria hespera* Miller
M. *Chaetarthria nigrella* (LeConte)
N. *Chaetarthria ochra* Miller
O. *Chaetarthria pallida* (LeConte)

The following lists present the sample number, cell number (subsample location), species, number of individuals, and sex of the specimens collected in samples 1, 2, 4, and 5. The lists are divided into 2 major sections, the first giving data on hydraenids and hydrophilids, the second on other Coleoptera which were present in the samples. The figures in parentheses indicate the number of each sex collected, with the first entry being the number of males. Preceding the parenthetical entry is an alphabetical designation which corresponds to the species present (see above list). (Note: females of *Chaetarthria hespera* and *C. nigrella* cannot be differentiated, therefore the alphabetical entry reads "L or M"; likewise, *Laccobius californicus* and *L. ellipticus* females cannot be differentiated and are therefore given as "G or I".)

Hydraenidae and Hydrophilidae

Sample No. 1: *H1V1*-J(3/4), G or I(0/1), D(0/1). *H2V1*-C(0/1). *H5V1*-L or M(0/1).

Sample No. 2: *H1V1*-J(4/3), H(2/0), A(8/5), D(1/0), E(1/0). *H2V1*-J(2/0), A(1/0), E(1/0). *H3V1*-A(2/2). *H4V1*-A(0/1). *H8V1*-K(0/1). *H9V1*-K(1/0), L(2/2). *H10V1*-K(1/0), L(3/5). *H11V1*-K(2/1), L(1/2), N(2/0). *H12V1*-K(1/6), L(8/2), N(0/1). *H13V1*-A(1/0), K(4/5), L(4/4). *H14V1*-K(5/5), L(2/1). *H15V1*-K(5/4), L(3/1), N(0/1). *H16V1*-K(1/2), L(0/1). *H17V1*-K(3/5), L(2/3). *H18V1*-K(1/0). *H19V1*-K(2/3), L(0/2). *H20V1*-K(1/2), L(0/2). *H21V1*-K(2/3), L(0/2). *H22V1*-K(3/1), L(1/1), N(1/0). *H23V1*-K(4/1), L(0/2). *H24V1*-K(0/4), L(1/2). *H25V1*-K(4/1), L(1/2), O(2/0). *H26V1*-K(5/3), L(2/2), O(0/1). *H27V1*-K(4/2), L(2/2), O(0/2). *H29V1*-L(0/1). *H7V2*-L(1/1). *H8V2*-L(1/0).

Sample No. 4: *H1V1*-H(2/2), J(5/5), G(4/0), I(3/0), G or I(0/10), A(0/1), E(0/2). *H2V1*-H(0/2), J(3/4), G or I(0/2). *H3V1*-J(2/2). *H6V1*-L(1/0). *H7V1*L(1/0). *H8V1*-L(1/0). *H9V1*-L(1/0), O(0/1). *H10V1*-K(1/0). *H11V1*-K(2/0), N(1/0), O(1/1), J(0/1). *H12V1*-K(1/1), O(0/1). *H13V1*-K(0/1). *H15V1*-O(1/0). *H10V2*-K(0/1). *H12V2*-O(1/0). *H14V2*-O(1/0). *H15V2*-O(1/0).

Sample No. 5: *H1V1*-B(1/2), A(1/2), G(1/0), G or I(0/1). *H2V1*-B(7/4), A(17/15), G(3/0), G or I(0/2). *H3V1*-B(9/6), A(45/35), G or I(0/1), F(1/0). *H4V1*-A(8/8). *H5V1*-A(5/1), B(0/1), F(1/0). *H6V1*-A(1/0), J(1/0), L or M(0/1). *H7V1*-B(0/1), F(1/1), L or M(0/1). *H8V1*-J(1/0), L(1/0). *H9V1*-F(1/0). *H10V1*-F(1/0). *H11V1*-L(1/0). *H12V1*-L (1/0). *H13V1*-L or M(0/1). *H14V1*-L or M(0/2). *H15V1*-L(2/0), L or M(0/2). *H16V1*-L (1/0), M(1/0), L or M(0/2), F(0/1). *H17V1*-L(2/0), L or M (0/4). *H18V1*-L(1/0), L or M(0/6), F(0/1). *H19V1*-L(2/0), L or M(0/10), K(1/0), F(0/1). *H20V1*-L(5/0), L or M (0/6), M(1/0), F(0/1). *H21V1*-L(2/0). *H22V1*-F(0/1). *H23V1*-L(2/0), L or M(0/2), F (1/0). *H24V1*-L(1/0), L or M(0/1). *H25V1*-L(1/0). *H26V1*-L or M(0/1). *H27V1*-L or M(0/2). *H28V1*-F(1/0). *H29V1*-M(1/0), F(0/1). *H30V1*-L(3/0), F(0/1). *H31V1*-L(4/0). *H32V1*-L(1/0), L or M(0/5). *H33V1*-L(1/0), M(1/0). *H34V1*-L(2/0), L or M(0/1). *H35V1*-L or M(0/1). *H5V2*-B(2/0), A(4/3), G or I(0/1), F(1/0). *H6V2*-B(1/0), A(1/1). *H7V2*-A(1/1), F(1/0). *H8V2*-B(0/1). *H13V2*-A(0/1), L(1/0). *H16V2*-M(1/0). *H17V2*-L (1/0), M(1/0). *H18V2*-L(1/0). *H19V2*-L(1/0), M(1/0). *H14V3*-L or M(0/1).

Other Coleoptera

Sample No. 2: H2V1-Staphylinidae (1 larva). H15V1-Sphaeriidae (5 adults). H20V1-*Limnichus californicus* (1 adult). H25V1-Sphaeriidae (2 adults). H26V1-*Omophron dentatus* (1 adult), Sphaeriidae (1 adult). H9V2-Staphylinidae (1 larva).

Sample No. 4: H3V1-*Heterocerus* sp. (1 adult). H8V1-Carabidae (1 adult). H10V1-Staphylinidae (2 adults).

Sample No. 5: H4V1-Helodidae (1 larva). H9V1-Staphylinidae (2 adults). H11V1-Staphylinidae (1 adult). H33V1-Staphylinidae (1 larva). H11V2-Chrysomelidae (1 adult). H14V2-Staphylinidae (1 larva).